FACSIMILE

by Dr A. C. GEE, G2UK

FACSIMILE (fax) is an electromechanical system for the transmission and reception of pictures and other graphic information from one place to another. It operates either over a landline, cable or radio system. The system has been in use professionally for 40 years or more, and in the last 10 years has developed very rapidly indeed, particularly in relation to specialized fields. Photographs for newspapers, weather maps, weather satellite pictures, documents, and fingerprint and "mug"-photo transmissions, to mention only a few.

Early activity

From the radio amateur's point of view, while there have been a few enthusiasts for the mode, little interest has been shown—if the lack of information about the mode is anything to go on. Some 10 years ago the author produced one or two articles, which were published in radio amateur magazines, endeavouring to stimulate some interest in fax. He enjoyed quite a lively correspondence after the appearance of these articles, but it soon became apparent that there was little point in pursuing the project very far at that time. There were numerous reasons for this; one of the most obvious being that suitable machines were not available at prices the radio amateur could afford. Another difficulty was that, as regards this country at any rate, special authorization had to be obtained from the licensing authority for permission to transmit fax, and, when granted, one's experiments had to be confined to the higher frequency amateur bands.

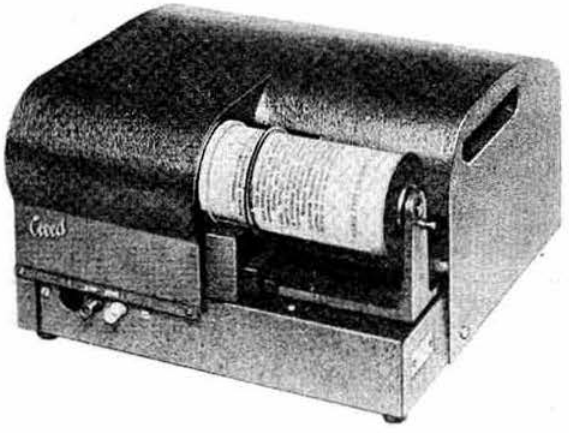
The reception of weather charts by facsimile, stimulated some interest in the mode among one or two enthusiasts. One was John Tuke, who actually built up the mechanical part of the system himself, and wrote a detailed description of it in one of the radio amateur magazines. This sparked off quite a lot of interest. Other descriptions of systems built up by enthusiasts using professional machines they had managed to acquire also appeared. About that time, there appeared on the surplus market some small compact machines called "Deskfax" machines. These were intended for use between offices, via the telephone system, for the transmission and reception of such graphic material as signatures, documents, drawings and so on.

Several of the companies associated with the manufacture of electromechanical equipment for the communications industry began to produce these machines. Creeds, Siemens and Western Electric were among those whose machines of this type were to be found. It seemed these would be just right for amateur radio use, and again there was a flurry of interest; descriptions appearing in the American amateur radio magazines on how to convert these for amateur radio transmission and reception and for the reception of weather charts. The recording material was called Teledeltos paper and was fairly readily obtainable. It was an electrothermally sensitive paper which changed colour when an electric impulse was applied to it, and it gave quite a presentable reproduction of the originals, which were scanned in a similar unit at the transmitting end by a spot of light. However, in this country the system did not catch on in amateur radio circles, no doubt due to transmitting licence difficulties, and the supply of machines dried up too; so again, little progress towards amateur radio fax was made.

At the beginning of 1977, new amateur radio transmitting licence regulations came into force, and fax was included in the modes which were authorized for use on most of the frequency bands allocated to radio amateurs, viz the 7, 14, 21, 28 and 144MHz bands. This concession immediately stimulated interest again in fax, and there is not doubt that, if suitable equipment can be found, this time we may see some activity in the field of facsimile appearing on these amateur bands.

The fax system

It might be as well at this point to outline briefly the system of facsimile transmission and reception for those who are not familiar with it. The picture to be transmitted is attached to a drum which can be rotated at a definite speed. A point of light is directed on to the rotating picture and is moved along to scan the picture at a predetermined rate. Light—which will vary with the characteristics of the picture—is reflected off it into a photosensitive device. The electrical output from this is conveyed, after suitable processing, either by wire or radio to a similar machine, where another drum rotating at the same speed, and of the same dimensions as that in the transmitting machine, carries paper upon which the



A typical "Deskfax" type of fax machine referred to in the text. These are fairly readily available from surplus sources - much more so than the "standard" fax machines, and can provide the basis for a limited "local" fax transmission and reception system to enable the enthusiast to gain experience

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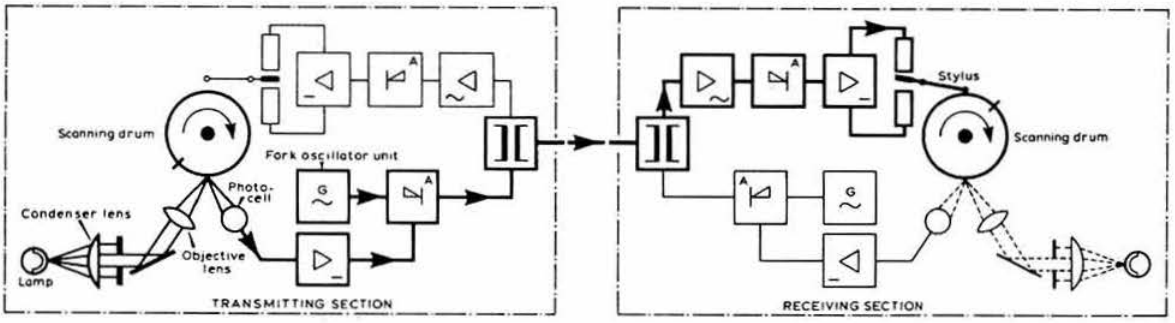

Fig 1. "Transceiver" arrangements for two fax units connected by landline so that pictures can be sent and received in either direction. Synchronization is provided by a tuning fork oscillator on one of the units. Transmission is by lamp/phototube arrangement; reception via the stylus

transmitted picture is reproduced. This paper may be photographic paper, in which case the receiving machine reproduces the transmitted signal as a varying light source, or it may be a special type of paper sensitive to electrothermal or electromechanical stimulation.

It will be apparent that if the above system is to work, a good deal of synchronization between similar parts of the transmitting and receiving machines is necessary. The drums need to rotate at the same speed, and the scanning of the picture in the transmitting unit must synchronize with that in the receiving unit. And the receiving unit must start up on an impulse from the transmitting unit or the two pictures will not correspond with each other. So it will be apparent that the system is a fairly complex one to get adjusted and to keep in adjustment if acceptable results are to be achieved.

Fig 1 illustrates a simple line-connected facsimile system in which, on the left, is the schematic for the transmitting unit. A tuning fork oscillator unit provides synchronizing frequency and power for driving the drum. The lamp system and phototube section are shown, and the resulting voltages are fed via a landline to the receiving unit. Here the synchronizing voltage from the fork unit in the transmitter is used to drive the receiving drum motor as well, and the voltages from the transmitter phototube are used to control the stylus carrying out the recording process.

Fig 2 outlines in schematic form the transmitting unit for a radio fax system. In this arrangement, the scanning drum is moved across in front of the lamp and photoelectric cell by the fact that it is mounted on a lead screw which, as the drum rotates, moves it along the screw. This is a method of scanning found in a number of fax machines and obviates the need for moving the lamp and photoelectric mechanism. Synchronization is provided by a tuning fork oscillator unit.

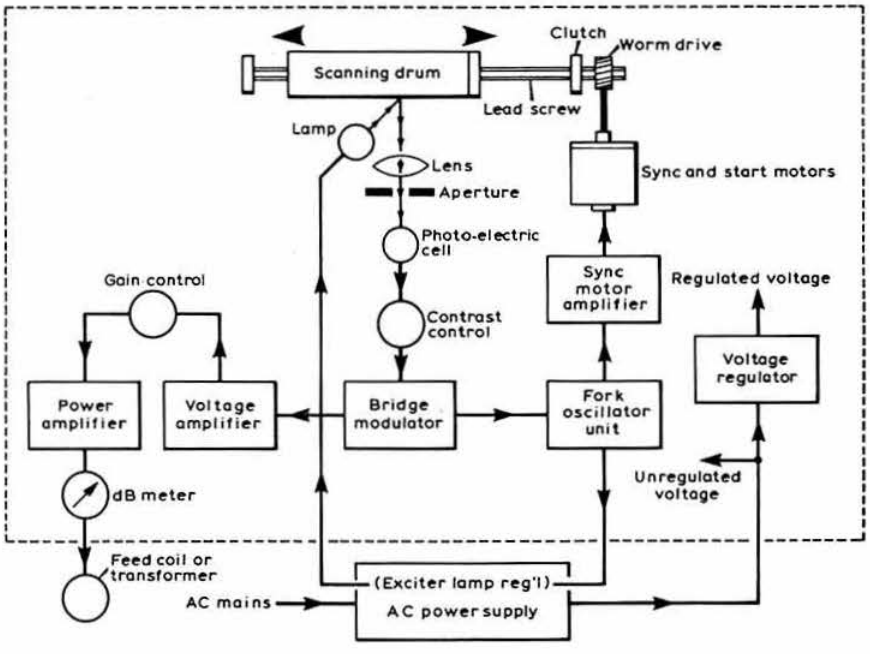

Fig 2. Transmitting block diagram

Fig 3 is the receiving unit schematic for a matching unit for the transmitter unit of Fig 2. Here the drum is scanned by a similar lead screw arrangement, and provision is made for synchronizing the start and stop of the drum. Recording is by means of a lamp system, and synchronization of the drum speed with that of the transmitting unit is assured by means of a tuning fork unit identical to that in the transmitter.

Fig 4 shows, in some detail, the arrangement of the lamp system in the transmitter unit, and how the drum moves along on the threaded lead screw, thus scanning the picture being transmitted.

Weather chart reception

Perhaps one should interject here a comment or two about the reception of weather charts by slow-scan, long-persistence cathode ray tube techniques. This is now the current method of recording the weather pictures of cloud cover, etc, transmitted by the various weather satellites. Photographs are taken of the images produced by this system and very good pictures are obtainable in this way. This is not true facsimile, however, and the system will not be dealt with further in this article. But it should be noted that the signals from these satellites can be recorded by an electromechanical machine of the type described above, and in fact they are often recorded in this manner as well as by crt systems.

Availability of equipment

The author was one of a small group of enthusiasts who were instrumental in introducing radio teleprinting (rtty) to the amateur radio scene in this country some years ago. This was only possible because at that time a number of suitable teleprinters came on to the surplus market at prices which the amateur could afford. Until a similar situation occurs in relation to facsimile equipment, it is unlikely that facsimile transmission and reception will become much in evidence on the amateur bands. However, one never knows. Once amateur rtty got going, it was quite surprising how quickly quite up-to-date machines began to appear on the surplus market, and much the same might well happen with regard to facsimile.

One of the difficulties which very soon raised its ugly head in regard to rtty, was that different machines worked at different speeds and had different code characteristics. Generally speaking there were two speeds in common use then, and much confusion, difficulty, annoyance and attempts at agreement were produced by these two standards. Most unfortunately, this situation is many, many, times worse with regard to facsimile! There are innumerable commercial standards in operation, and if these machines do come on to the surplus market there is likely to be much confusion!

Anticipating these problems, the Deutscher Amateur Radio Club EV produced a proposal at the International Amateur Radio Union, Region 1 Conference at Warsaw in 1975, for introducing "standards" for amateur radio fax. This was a very good move, and these proposals formed the basis for discussions which have since taken place, and which will be reported in a future issue of *Radio Communication*.

Apart from the obvious advantage of having a set of standards to which all participants should endeavour to work, there is one paramount consideration of a very practical nature—that is that the fax enthusiast should be very careful to ascertain the characteristics of any machine he might find on the surplus market and which he is contemplating purchasing. As we have indicated, there is such a variation in the parameters used in

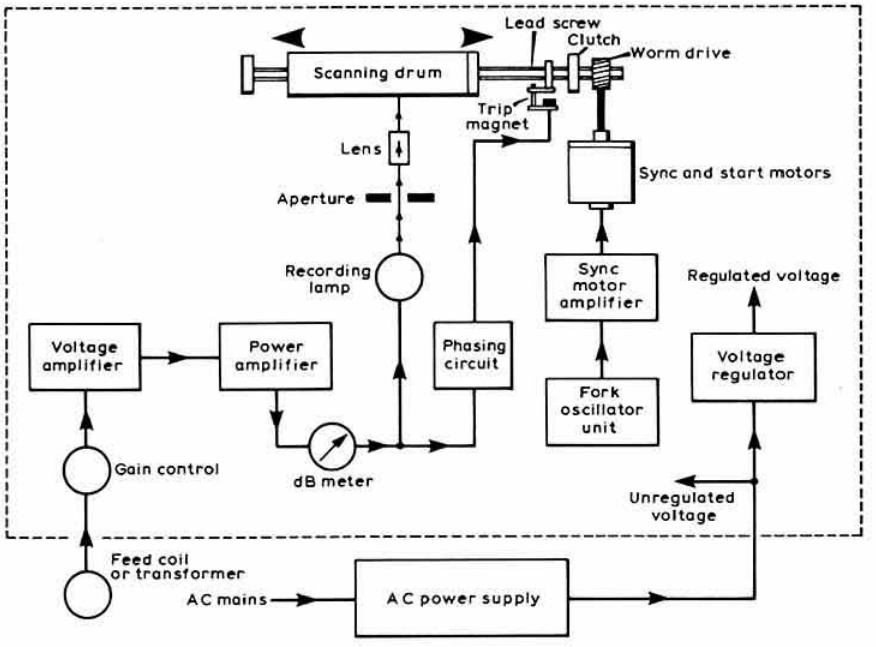

Fig 3. Receiving block diagram

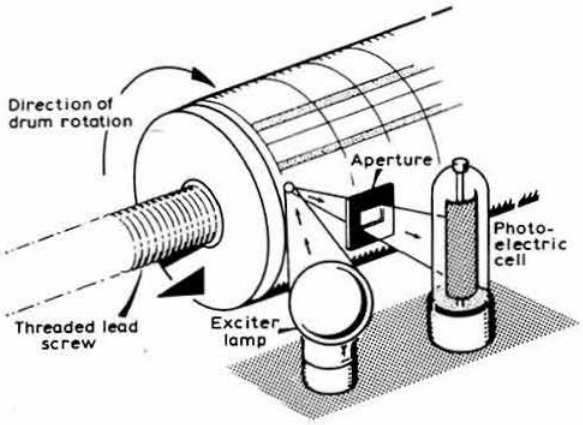

Fig 4. Arrangement of lamp system in typical fax transmitter

commercial practice, that it is even more important than it was in the case of rtty, to be sure to get a machine which is compatible with others in the service one wishes to participate in. The important parameters to consider are:

Drum speed. In commercial practice, speeds of 60, 90, 120 and 240rpm are found. However, 240rpm is considered to be rather too high for hf radio links; 180rpm is also in use, as is 100 and 150rpm in the specialized types of machine such as "Deskfax" machines.

The drum speed is of some importance in commercial practice, as the length of time required to send a picture—and consequently the cost—depends on the drum speed. A 22 by 18in weather chart takes 18min to send at 120rmp; 24min at 90rpm and 35min at 60rpm. The drum speed is not all that important to the radio amateur, except in so far that one must have the same speed available on one's fax machine as the other chap is using.

The index of co-operation. This is a figure given by multiplying the number of scan lines per inch, by the drum diameter in inches. Thus a machine with a drum diameter of 3·52in and a scan pitch of 100 scan lines to the inch, has an index of co-operation of 352. If there is a difference in the ioc between one machine and another, there will be a difference in the height: width ratio of the reproduced picture compared with the original. This may or may not be of importance. In the case of, say, mechanical or architectural drawings or navigation charts, it is obviously of great importance, but in the case of documents, some pictures, etc, the difference may not be so important. Weather chart facsimile is standardized at an ioc of 288 or 576. For radio amateur use, the ioc is possibly not quite such an important standard as it is in professional work. Though, maybe, when the yl operators take to fax they might well be a bit put out if their portraits came out short and fat, whereas in reality their figures are tall and slim!

Other factors. There are numerous other factors which have to be considered in getting the transmitting and the receiving units compatible, but there is not space here to consider them in detail. The direction of scanning is important, ie whether the picture is scanned from left to right and from top to bottom, or vice versa. If a picture is scanned in the wrong direction, the most awful *faux pas* may occur, such as a right-handed batsman appearing as a left-handed one, or a row of medals on the chest of a prominent personality appearing on the wrong side! And then there are such matters as phasing signals, starting signals and synchronization to consider.

Perhaps something more can be said about the latter. Earlier commercial practice was to use an electronically-driven tuning fork to provide a synchronizing source of power to drive the motors driving the drum on the transmitting and receiving units. These forks had to be tuned up to pretty tight tolerances. If a fork vibrating at a standard frequency of 1,020Hz was as much as 0.6Hz out of frequency, this was an "out of tolerance" degree sufficient to ruin the picture reception. Nowadays the synchronizing power is generated by a crystal oscillator system, and this is obviously the system which would be the most suitable for the radio amateur. Presumably, however, if two fax enthusiasts were located sufficiently close to each other on the same ac mains supply, and they wanted to try out experiments with fax between each other's QTHs, it would be satisfactory to use the mains as the drum drive power source, as synchronization in these circumstances would automatically be taken care of.

What then are the possibilities for amateur radio fax?

First of all, one could limit one's interest to the reception of fax broadcast signals. Much interest and a lot of valuable experience can be derived from setting up gear to record weather maps. It might not be too difficult to find suitable machines at prices one can afford. These machines usually have a recording system—electrothermal or electrochemical—which does not require darkroom facilities. So this is probably the best approach for the "beginner" fax enthusiast.

Alternatively one could go straight for a transmission/reception project, working with a fax enthusiast friend located not too far away. For this project one could use the "Deskfax" type of machine, of which there are a few around, which can be obtained at reasonable prices. Furthermore, there are several enthusiasts who have had experience with these machines and have got them working. Teledeltos paper for these machines is also available, as are manuals, though the latter do take some finding!

One must remember, however, that these machines have "standards" all of their own and they will not be compatible with the more normal fax machines, needed for weather chart reception, working with other fax stations overseas, reception of "broadcast pictures" etc. Furthermore, "standards" vary between different models of these "Deskfax" machines themselves. The Creed type TR100/1 has an index of co-operation of 200, while the TR102/1 has an ioc of 260. Both machines have a drum speed of 150rpm, not one of the now "universal internationally recommended" drum speeds which are all in multiples of 60rpm. However, these small machines do offer the opportunity of getting going on fax transmission and reception and, bearing in mind the limitations indicated, they do give the fax enthusiast something to experiment with.

Conclusion

The author hopes that this article will have given the reader some idea of the present state of the art fax-wise; indicated the broad principles of the system, and the difficulties which have to be overcome in setting up a fax amateur radio station. From the radio amateur point of view, the system offers plenty of challenges, and anyone looking for a hard nut to crack will find it in fax as so little in equipment or in information is readily available to the amateur. However, this is amateur radio at its best and, now that the licence regulations have been eased, without doubt the other difficulties which have to be surmounted in introducing fax to the amateur radio scene will in due course be overcome.

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by Pat Hawker, G3VA

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